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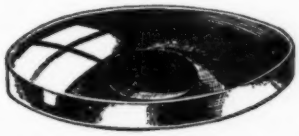

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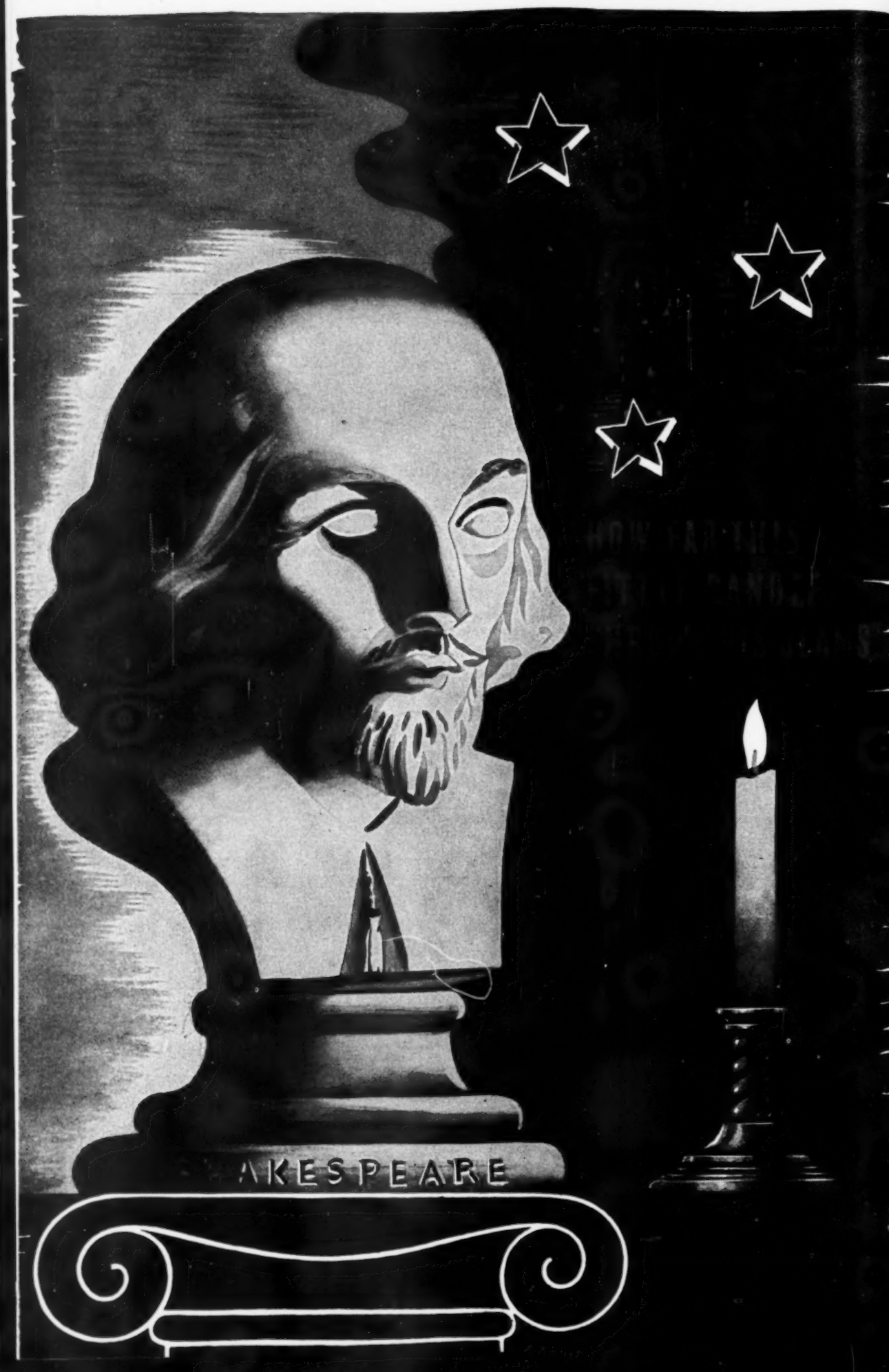
AKESPEARE

AMERICAN JOURNAL OF OPTOMETRY

Vol. 15 JANUARY, 1938 No. 1

AN EVALUATION OF EYE-MOVEMENT MEASURES FOR OPTOMETRISTS*

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Optometrists are fast becoming eye-movement conscious from a new point of view. Certain recent developments in their own and in related fields have emphasized the possibility that greater efficiency may be achieved by taking account of the eye-movement patterns that occur in reading, in visual fixation and during interfixation excursions. The ophthalm-o-graph, a camera for photographing eye-movements, has been recently developed, and is practical for office use both in size and simplicity of operation. The photographic records furnish a strictly objective measure of oculomotor behavior during visual work. Various reports on eye-movement studies of ocular behavior are appearing in *this journal*. In addition, the attention of optometrists is being directed to reports of eye-movement studies printed in psychological journals. A recent book by Taylor[3] and pamphlets[1, 2] issued by the American Optical Company explain in detail the uses of eye-movement photography as related to optometry. All these sources of information have stimulated among optometrists a keen interest in oculomotor behavior as revealed in photographs. Some optometrists are already conducting experiments of their own and others are probably employing the eye-movement camera in clinical diagnosis. In light of this interest and activity it seems desirable that there be a clear understanding of the meaning and significance of eye-movement measures of oculomotor behavior in order that the measures may be employed to best advantage.

This paper is not meant to discourage the photographing of eye-movements by optometrists. Rather, it is intended to point out certain cautions concerning assumptions and procedures as well as the need for a critical analysis of results in order that the optometrist may protect himself from errors of interpretation.

In reading, the eyes make a series of fixation pauses along the line

*Submitted for publication Dec. 6, 1937.

of print. The saccadic movements or "jumps" from one fixation to the next are comparatively very rapid. In fact, it has been shown that these saccadic moves are so fast that no clear vision occurs while the eye is in motion. Perception in reading takes place, therefore, only during the fixation pauses. It has been demonstrated[4, 10] that, on the average, 93 to 94 per cent of the reading time is devoted to the pauses and only 6 to 7 per cent to the moves. This ratio is remarkably constant from one type of reading material to another[10]. For practical purposes the movement time may be ignored and total pause time (perception time) taken as the reading time.

The eye-movement measures obtained from a photographic record are the following: (1) Fixation frequency is merely the number of fixation pauses per line, per selection of reading material, or per 100 words. (2) Regression frequency is the number of backward (to the left) movements within the line of print made per line, per selection, or per 100 words. The return sweep of the eyes from the end of one line to the beginning of the next is not classed as a regression. (3) Pause duration is the amount of time taken by each pause. The unit of time employed is usually 1/25, 1/50 or 1/100 second. (4) Perception time is merely the sum of the pause durations. From these measures one can derive the number of words read per minute or per fixation.

The reliability and validity of the eye-movement measures have been investigated by Tinker[9]. By reliability is meant the consistency that occurs in performance from line to line or from paragraph to paragraph when a person is reading. It was shown that all the measures are highly consistent. Satisfactory reliability for the reading of a single person is achieved, however, only if at least 20 lines of print are read. By validity is meant how truly do eye-movement photographs measure reading performance. Perception time is a highly valid measure of reading for it yields the total time of perception during reading. It has been shown by statistical analysis[5, 7, 9] that fixation frequency yields a true measure of reading and, therefore, is a valid measure. Regression frequency, however, is only a fair measure of reading and pause duration is a poor measure. The simplest photographic measure of reading that is both reliable and valid, therefore, is fixation frequency.

The eye-movement record of a good reader shows a marked contrast to that of a poor reader. Consistent progress of fixations from the left along the line of print (few regressions) with the few fixation pauses per line usually indicates clear understanding and rapid assimilation of the textual material. This characterizes the good reader. In contrast to this the poor reader makes many fixation pauses and frequent regressions in each line of print. This type of performance reveals poor comprehension, slow and laborious assimilation of the materials. While the good reader may make about five fixation pauses per line, the poor reader is apt to make as many as nine or ten fixations with more regressions.

It cannot be too strongly emphasized that eye-movement patterns are external manifestations of the internal conscious processes during reading. For the most part eye-movements do not condition or determine proficiency of reading. On the contrary, they reflect reading status. The patterns of eye-movements are, therefor, symptomatic of the central processes of apprehension and assimilation which occur during reading.

Much too great prominence has been given to the term "rhythm reading." It suggests an assumption which is not justified. A few have argued for and many have accepted uncritically the notion that rhythmic eye-movements produce efficient reading. It is assumed that once we have conditioned occulomotor mechanics so that few fixations and few regressions are made (i.e., "rhythm reading") that this condition automatically produces more proficient reading. This assumption has led to training such as "pacing" eye-movements to improve reading. After examining the pertinent evidence, Tinker[8] concludes that there is no evidence that training eye-movements as such develops effective oculomotor habits which improve reading ability. On the contrary, eye-movement patterns merely reflect proficiency of reading status. The caution to keep in mind is that the clinician should be careful not to overemphasize peripheral factors (condition and behavior of the eye) as determinants of reading. The central factors of perception and assimilation are of greater importance.

The implications of these conclusions are clear. There are two principal means of measuring reading status in the clinical situation: (1) by the use of standardized reading tests: (2) by photographing eye-movements. The results from these two methods will correlate highly. This means that the two techniques are approximately equivalent and that the more convenient may be employed. Ordinarily, the use of the standardized test is easier to handle the less expensive. The use of the photographic method, therefore, must be justified on other grounds. It is sometimes advisable, of course, to supplement reading test scores with eye-movement records. It is more convincing to show a reader an objective record revealing too irregular and too frequent fixation pauses than to merely tell him that he reads too slowly.

There is information concerning certain aspects of reading performance, of course, that can only be obtained from eye-movement photographs. Several of these may be listed: (1) The oculomotor patterns, consisting of the frequency, placement and duration of fixations, give important clues to the location of special difficulty in comprehension and assimilation whether this happens to be a difficult word, an incomprehensible formula, or something else. (2) Photographic records will give objective records of accuracy of fixation following saccadic moves or during continuous concentration upon a visual object. Some readers fail to hit the proper line on the return sweep from the end of a line just read to the next line. They may skip a line or start reading the same

line over again. Other readers do not go far enough on the return sweep and have to make one or two regressions to perceive the first word in the next line. Photographic records will reveal the kind and amount of errors in such cases and suggest remedial treatment. In other instances, inability to fixate a point accurately at the end of a saccadic move, and the number and amount of corrective movements necessary to complete the fixation are readily shown on photographic records. (3) It is well established that the eyes converge somewhat during saccadic moves and that they then make diverging adjustments on coming to a fixation at the end of the sweep. Photographic records may be employed to check for abnormal degrees of convergent and divergent movements. (4) The optometrist frequently encounters lack of muscle balance in binocular vision. An objective check on kind and amount of abnormal muscle balance can frequently be made by photographing the eye-movements. Types of poor coordination that can be recorded on the film include: The tendency for one eye to deviate off to one side, irregular looping movements and jerks of one or both eyes on approaching fixation, and inability for both eyes to maintain coordinate fixation of a point in the visual field.

Summary

There are two uses to which the optometrists can put eye-movement records: (1) They may be employed either in place of or as a supplement to reading tests in analyzing the reading status of a subject. Choice of the photographic method should be determined in terms of economy of time and cost, the particular interest of the optometrist, and the need of additional emphasis in dealing with the patient. Evidence indicates that eye-movement records are not indispensable in clinical diagnosis of reading status[8]. (2) Perhaps the most profitable use of photographic records is for an objective check on such abnormal deviations of oculomotor behavior as results from muscle imbalance, inaccurate fixation movements and the like.

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PREVENTION AND CORRECTION OF OCCUPATIONAL MYOPIA*

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Small degrees of low acuity apparently corrected with weak minus lenses—accompanied with ocular discomfort and an esophoric tonicity—do not always denote a genuine condition of myopia, but are due mainly to working under conditions favorable to the setting up of the symptoms.

Few of us today are working under conditions for which Nature originally intended us. Early man presumably lived outdoors, retiring only to shelter when darkness, sickness, or some other natural reason, impelled him to. Skulls dug up, which anatomists state are many thousands of years old, almost invariably retain traces of teeth, perfect in regularity and condition, and with traces of physique which today would be described as abnormal. Whilst no records of vision are available, from the fact the so-called savage tribes of today who to some extent retain the simple habits of our early ancestors, usually have the same characteristically fine physique, teeth, and remarkably keen vision, we may suggest with some confidence that man, in the dawning of the world, did possess super acuity. His very livelihood depended upon his vision to see his quarry both by short or long distances.

Even with the development of the arts and sciences, in the pre-Christian era, when sculpture reached the highest pitch, when enamel and metal work of almost incredible beauty was created, the ability to record and decipher was but the possession of a chosen few. The mass of the people still lived in the open for the most part, and, for want of proper artificial illumination, rose with the sun and retired at its setting.

It is significant that the diarist Pepys, one of the few men possessing the art of penmanship in an age when reading and writing were not yet universal accomplishments, was compelled to stop his writings by reason of failing eyesight, which many ascribe to presbyopia.

According to Pansier in his paper, "A History of Spectacles"

*An abstract of the Third Owen Aves Memorial Lecture delivered before the Yorkshire Optical Society, Leeds, England, and printed in *The Refractionist*.

(*Dioptric Review*, Vol. 9, No. 94, p. 335), there was no mention of glasses for myopes until the end of the fifteenth century. It is recorded that Pope Leo X (1475-1521), was a myope, and made use of a concave glass when hunting. This knowledge is accredited to Luke Gauric.

We are indebted to Kepler for the earliest definite knowledge of the nature of myopia. In his "Paralipomena" (1604), and "Dioptrica" (1611), he showed for the first time that in myopia the rays from a distant object focus in front of the retina, and he explained the influence of concave lenses in the production of better vision. He attributed the defect to focal shortening caused by increased curvature, index errors, and forward displacement of the lens. A Dutch physician, Plempius, was the first to attribute the error to be due to abnormal length of the optical axis ("Ophthalmographia," 1632). The observations of Plempius were verified by the Italian anatomists Morgani (1761), and Scarpa (1807).

According to Ettles, the existence of myopia was known in early times, and actual descriptions of it are given in the works of Galen, Hippocrates and Aristotle. Speculations regarding its nature were, however, fantastic, the accepted view being that it was a weakness of "optic spirit." Donders clarified a great deal of our knowledge concerning myopia, and he it was who attributed the defect to close work, because (1) the stooping position necessitated by the nearness of the far point causes congestion of the head and eyes, and (2) pressure of the external recti on the eyeball in strong convergence.

An analysis of the old spectacles in the British Optical Association museum, shows an enormous preponderance of those glazed with plus lenses. Granted that there was formerly an objection to the wearing of glasses out-of-doors, had there been a real demand for minus lenses, they would have been worn whether fashionable or not.

In an address given at the proceedings of the Optical Convention in 1926, by Owen Aves, on the relative distribution of refractive defects, we find, in an analysis of 2,500 cases, 1,896 are near point workers, and the remainder—604—what he terms mental and professional. Of the near point workers, 1,151 are mostly women, machinists, dressmakers, etc., and 516 are clerks and stenographers.

In the same paper, we have an analysis of 916 eyes fitted with concave spheres. 109 are —0·25, 210 are —0·50, 60 are —0·75, and 152 are —1, making 362, or nearly 40 per cent, or, taking —0·25 and —0·50 above, we get 210, or about 22 per cent.

In 5,000 eyes requiring minus cylinders alone, 2,161 were no stronger than —0·25 and —0·50, whilst in 1,015 cases requiring minus cylinders with minus spheres 503, or 49 per cent, were divided as between 0·25 and 0·50 respectively, the actual figures being 261 and 242.

Whilst these figures do not altogether prove the case for occupational myopia, they certainly show a strong suspicion. Although presented in

1926, they are somewhat confirmed by recent enquiries made at two large prescription houses, whose percentage of low power minus lenses used over the whole range of prescription work reached, in one case, 10 per cent, and in the other 12½ per cent.

The record of school clinic work, if collected, would, perhaps, show figures of equal significance, although, unfortunately, I understand that the preliminary weeding out is performed by teachers in the schools under very unscientific conditions, and with a comparatively low standard, passed as satisfactory. In other words, unless the children actually complain of ocular discomfort, only those with really low acuity are sent for eye examination.

These facts and figures suggest that myopia is a product of civilization, and as we become more industrialized, so will the defect increase.

Whilst prevention is the ideal, it is, perhaps, unattainable, and if we can devise some method whereby, in correcting an established disturbance, we can, at the same time, inhibit its recurrence, it is, perhaps, as much as can be expected.

I suggest quite definitely that a very large proportion of patients who, at first examination, apparently require weak concave lenses, are not, in the true sense, myopic, i.e., their refractive error is not due to increased antero-posterior axial length.

Furthermore, even when real myopes present themselves for examination, not only, in many cases, can progression be stopped, but even weaker concave lenses be given that will give equal, or better, visual acuity.

For the successful treatment of these cases, a thorough investigation of the phorias and ductions, and refraction balance both at distance and at the working distance, must be made. In this connection, it is as well to ascertain what is the correct working distance. To assume it is thirteen inches, and make deductions from this point, is if not actually fatal to success, at any rate a decided handicap. Furthermore, all muscle investigation must in the first place be taken without correction—and if the patient is already wearing glasses, results in addition should be recorded whilst he actually has them on.

Perhaps the Kratometer may be regarded as the ideal instrument for investigation and treatment. Its cost, however, consequent upon its being of foreign origin, debars it from many.

The variable prism stereoscope is a thoroughly reliable piece of apparatus, its low cost and general handiness making it a great favorite. In fact, when provided with suitable targets, such as are used in the Kratometer, it will do its job almost as effectively as the more expensive instrument.

A very useful instrument is the Maddox prism verger, which can be used both for diagnosis and also for home treatment. Unfortunately, the standard model cannot be used for near point adduction, as the

prism range is low, also any correcting lenses have to be worn in a trial frame. A clip can be obtained for holding correcting lenses, and also an additional base in prism for taking the positive fusion reserve.

Where diagnosis has already been made, a commercial stereoscope can be used for home training, whilst an even simpler piece of apparatus is suggested by Dr. Maddox in his book *Ophthalmic Prisms*, in which he writes as follows:

"I never now prescribe square prisms, since patients rarely hold them correctly, but find it better to order prisms mounted in ordinary circular-eyed spectacle frames. Instead of replacing these by stronger prisms as the exercises become able to be made more severe, the better plan may be recommended of prescribing at first two rather strong prisms with their apices pointing upward, but slightly divergent or convergent, so as to afford the resultant prismatic effect required for the first gentle beginnings of the treatment. On each visit of the patient, the angle between the apices is increased by slightly rotating the prisms in opposite directions and fixing them again." . . "How is the patient to use these fixed exercising prisms? At first intermittently, by looking for brief intervals at distant objects, or, if that be found difficult, approaching the objects first, and then receding from them with the spectacles on until diplopia threatens. When the eyes have learned to conquer this diplopia, the spectacles should be worn more permanently, say for half an hour at a time, whenever the nervous conditions are strongest, as after breakfast, or after dinner. In some cases the prisms can be worn almost all day until the heterophoria is finally cured."

Provision should also be made for a pair of Lockwood cross-cylinders: —0·25 cyl. with +0·25 cyl., which gives the effect of —0·25 sphere with +0·50 cyl., or vice versa. They should be used with the plus cyl. axis horizontal.

The problem of myopia reduction can be resolved into a system for the inhibition of eso, by encouraging abduction.

Dipping into the writings of our friend Peckham we find: "The esophore should have a convergence relaxation of four or five times the amount of manifest esophoria, to avoid headaches. If there is an eso. of 3△, there should be present a relaxation of at least 12△. If this proportion is shown in the abduction test, there will be little discomfort due to esophoria."

Also he says: "In that type of myopia due to close association of convergence and accommodation, one-third of the amount of the abduction can be safely prescribed for constant wear, as such base in prisms actually relax the accommodation enough to permit the prescriber to weaken lenses with equally clear or better vision afforded by stronger minus lenses without prisms."

As I shall be using certain terms, it is as well for all present to have

a clear idea of what they mean. *Displacement Prism*=a Von Graefe vertical prism, base up or down, of sufficient power that the eye cannot overcome its effect. We usually use 6△ divided as between 3 base up before the right eye, and 3△ base down left eye. Thus, with these prisms in situ, two images are seen, one belonging to each eye, the higher belonging to the left. In cases of Eso or Exophoria, the two images are brought into vertical alignment by suitable horizontal prisms. This method is generally to be preferred to that of employing a Maddox Rod, in which fusion usually takes place before alignment is actually reached, and the former method has the further advantage in that it can be used both at the near point, and at 6 metres. By Duction we mean the ability of a pair of eyes to maintain binocular single vision at the distance test. Emphatically, duction tests do not indicate the strength of the Recti or Oblique muscles. Maddox says: "It must not be imagined that a base in prism measures the strength of the external Rectus. It only invokes a slight contraction of that muscle, but a fraction indeed of its full power of turning the eye towards the outer canthus."

More strictly speaking, duction tests measure fusion. They are, fundamentally, quantitive analyses of the delivery of innervation from the appropriate centres. Duction is fusional, and under the control of the fusion centres operates in the interests of single binocular vision. If in an eye the image is displaced to any part of its fusional domain, the fusion faculty will move the macula to it, when possible. The expression "when possible," is of importance. Savage in "Ocular Myology" says: "When the image is thrown by a stronger prism entirely outside the field of fusion, the guiding sensation, which seems to reside in this area only, will not call on any muscle to move the eye for the purpose of fusion." The nasal limit of the retinal area as measured by a prism in front of the eye is normally about 8△, the temporal limit 25△, and the upper and lower limits 3△ each. This, of course, is for 6 metre fixation, and will vary for nearer fixation points.

DUCTION DETAILS

Duction	*Muscle involved*	*Measured by prism*	*Average value at 6 metres*
Abduction	External	Base in	6/8
Adduction	Internal	Base out	16/25
Superduction	Superior	Base down	2/3
Infraduction	Inferior	Base up	2/3

Where accommodation at nearer distance is brought into play, these values are generally increased.

A useful mnemonic for remembering the position of prisms is:

Pabbin=Plus prism, measuring abduction, base in.

Madbout=Minus prism, adduction, base out.

Plus prisms are so denoted for the reason that base in prisms induce

abduction and so relieve convergence and through associated reflex, accommodation also.

This, by the way, is suggested in *The Ophthalmic Optical Manual,* by Mr. C. Swain.

Whilst adduction may be said to measure the power of convergence, it might also be considered as the ability of divergence to relax, and similarly, abduction as the ability of conversion to relax. Peckham says: "The amount of abduction at distance is of importance in esophoria, and should be taken in that type of myopia due to excessive con/acc. efforts, and will indicate how much base in prism can be successfully worn in the attempt to relax acc. and reduce myopia."

Speaking of phorias and tonicity tests, I am indebted to Mr. C. Sheard, the eminent American physiologist, for the following, the gist of which he delivered in an address before the British Optical Association some few years ago.

"A pair of eyes may be likened to a team of horses controlled by a teamster. The muscles are the reins by means of which the teamster, i.e., the controlling nervous centers, co-ordinates the pair of horses, or pair of eyes, as the case may be. The vital question is: Are these horses, or are these eyes, so co-ordinated and harnessed together as to permit of an efficient and economically functioning pair, or are they maintained in co-ordination through the expenditure of excessive nervous energy? To return to the analogy of the horses: Do they tend to bite each other's necks, or do they strive to pull away from each other, one to the right, and one to the left? Or is one horse always lagging behind the other, so that the driver has to constantly restrain one horse, or constantly whip up the other? To anyone who is appreciative of what this situation means, there will come an immediate realization of the significance of the drain upon the nerve centers involved in the case of pairs of eyes which, perchance, may tend to excessive convergence, divergence, or hyperphoria, or may actually be in a condition of over-convergence (esotropia), divergence (exotropia) or vertical imbalance."

Duction may be regarded as assets and phorias as liabilities, a knowledge of one being useless without that of the other.

The fixation target in duction and phoria tests should not be a spotlight, but preferably a letter "E" on a background which shows nothing else. This will better enable the patient to detect immediate signs of blur, or recognize blur point.

It has been stated that there are no direct connections between the fovea proper and the brain centers controlling movements of the eyes. These connections are in the area surrounding the macula. Therefore if we attempt to fuse a spotlight, on account of its small size, it is not the light that is fused, but the dark area surrounding it. It is fairly well established that spotlight fusion shows a smaller amount of duction than that made with a larger picture as a target.

Break. When the prism has become so strong that the two eyes can no longer retain single binocular vision, two images begin to appear, and this is known as the break point, and actually measures the power of the fusion center, and the innervation delivered to any particular muscle.

Recovery. This is the point where, the prism having been gradually reduced, the image again appears single. The Recovery point is of the utmost importance, and should never be omitted in duction taking, either at near or far. Low Recovery points usually require further investigation of color fields, as this condition may arise from some focus of infection.

We will assume that a patient presents herself, with a history of ocular discomfort at near, perhaps finding some difficulty in seeing omnibus numbers, and cinema screens. Duration of symptoms—some months past. Occupation necessitates a very close near point, complicated perhaps by bad lighting conditions, such as unshielded lights shining into the eyes. V.A. may be 6/12, corrected by weak minus lenses of, say, —0·50 to 6/6.

Those who live in industrial districts will recognize this as a symptom of frequent occurrence. I live near a large factory, where young girls are engaged for several hours a day handling lamp filaments, wireless valve filaments, and extraordinarily thin wire, which I, personally, can hardly see to pick up. Their occupational position is something like 8 inches, representing 5D. of accommodation, and 30M. angles of convergence, in a person with a 60 mm. P.D.

It is a theory which seems to be supported by fact, that whilst convergence is volitional, i.e., under control of the individual, accommodation is purely automatic. Furthermore, the converging effort can be a very strong one, much more sustained than that of the accommodation, by reason of the fact that the recti muscles, and the innervation supplied, are so much more powerful. Accommodative relaxation becomes lessened in the tiring struggle to keep up with adduction. The condition of spasm becomes established, together with reduced acuity at distance.

A further definite factor in the development of the pseudo-myopia lies in unshielded light causing pupillary contraction—a further innervation to accommodation by associated third nerve reflex.

In correcting this false myopia induced by spasm, there are various methods. Atropine, fogging, and relaxation exercises, can be quoted as three, each with its own adherents.

The use of cycloplegics to a near point worker is contra-indicated by reason of inability for the patient to carry out his or her accustomed daily routine. With the labor market as it is, this is perhaps the last thing to be desired by an employee. Cycloplegics again prevent any registration of n.p. duction, phorias, or of stereoscopy, without a knowl-

edge of which perfect ocular balance cannot be given.

Fogging has its adherents, but, apart from the definitely lowered distance acuity, over, perhaps a lengthy period, the mere unlocking of spasm is no guarantee that it will not occur again whilst working conditions remain the same.

I definitely suggest that only lasting benefit can be obtained by use of base in prism prescribed after a thorough investigation of muscular condition and working distance accompanied, of course, by suitable convergence relaxation exercises.

SUGGESTED METHODS FOR THE REDUCTION OF MYOPIA

(1) Increased amount of abduction in case of esophoria will sometimes free the patient from headache.

(2) Exercise with prism base in to encourage inhibition of innervational convergence.

(3) In occupational and false myopia, we must attempt to separate innervational accommodation from the convergence which has brought on the condition.

(4) With a pair of Lockwood cross cyls. used binocularly at working distance in conjunction with a displacement prism and suitable targets, latent hyperopia may become manifest. Amount shown under the test will probably not be accepted until some time later.

(5) The ideal to be aimed at is to build up the convergence relaxation, i.e., abduction, so that prisms base in can be used with weaker minus lenses, then prisms alone, and finally endeavor to reach a condition of emmetropia.

(6) Persevere with the cross cyl. test to bring out latent hypermetropia.

(7) In all cases of myopia, especially progressive, keep on the convergence relaxation exercises and prescribe prisms, base in.

(8) Convergence exercises consist in the main of using base in prisms with a large, easily seen picture at distance, or, at near, some simple design. Increase or decrease prism power by small steps, jerkily at first, but more rapidly afterwards. In no case use small print as a target, which will only excite accommodation.

(9) At first try to avoid actual diplopia, and reduce as soon as blurring commences.

(10) To encourage relaxation, endeavor to use a pair of weak plus spheres (+0·50 D.) in the front cells of any instrument you may be using.

(11) Look out for suppression in esophoric cases—otherwise you will be exercising only one eye at a time, and will get entirely misleading results.

(12) The F and L chart is as good as any. The ON NE is a useful

variant. Septum must be used, also reading correction with P.P. distance carefully adjusted. Use the Genothalmic card with the crossed line design for the purpose of checking any sectional astigmatism.

(13) Start with about 20△ base out, 10△ before each eye. The amount will somewhat vary with the individual. If an E is seen at once, and held, there is no suppression. If patient sees at first only F and L, increase base out until he sees E. If he sees L and F, there is too much base out.

(14) If he sees F alone, right eye has suspended, if L alone, left has suspended.

(15) If suppression is very marked, use a dimming disc before dominant eye, for preference smoke. Avoid use of red discs, which excite accommodation—the last thing to be desired.

(16) When prism power has been found that will just fuse F and L into E, take abduction reserve.

(17) *Abduction Reserve* is found by decreasing base out. When the F and L breaks and cannot be re-fused without alteration of prism power, limit of abduction has been reached. An individual with really good relaxation (abduction) will fuse without any base out in position, or even with a small base in—though the latter is exceptional.

(18) The amount of Convergence relaxation, is the difference between the amount originally required to fuse F and L, and the amount of power denoted just before the E breaks again into F and L.

(19) *Adduction Reserve,* or fusion reserve, is the difference between the amount required to fuse F and L and the power denoted when the E commences to break into L and F.

(20) *Examples.* Power required to fuse =20△ base out (10△ each eye). E commences to separate into L and F at 40 base out. Adduction reserve =20△, i.e., 40△ minus original 20△.

Abduction reserve power of prism required to fuse F and L into E = 18△. It can still be held at 6△. Therefore abduction reserve = 12△.

(21) When any suppression has been eradicated, and relaxation reserve built up by slow adjustment, attempt faster movement of prisms, Power, Speed and absence of fatigue being the goals to be aimed at. In addition to suppression, hyperphoria must be looked for.

SUGGESTIONS AS TO PRESCRIBING

(a) Find the lens that will give the best visual acuity, being careful not to over-correct.

(b) Be very careful that the minus lens selected does not increase eso at distance, or even decrease exo. If there is any tendency, stop adding minus immediately increase begins. Disregard acuity in these cases.

(c) With lenses in position, take distance abduction, using a large target. In testing, prism power over each eye must be equal. Find breaking point, or just before, and then recovery as before explained.

(d) Use the amount of recovery, to be worn half before each eye and

(e) Find acuity with these prisms only, adding minus until patient obtains 6/9.

(f) If patient insists on 6/6—many will not be satisfied with lenses giving worse acuity than their existing ones—give bifocals for constant wear, with, of course, the base in. The working segment can be obtained as a rule from the binocular cross cyl. test. For working alone, the patients may be persuaded to use plus correction with base in (or weaker minus with base in).

(g) Continue relaxation exercise.

(h) Recheck Rx every month, adding more base in prism, and using less minus as may be necessary.

(i) Insistence must be emphasized that no bright unshaded lights are allowed to shine on eyes at work, and thus cause pupillary contraction, perhaps associated with reflex accommodation. If working conditions are such, let patient use a tennis shade over the forehead.

(j) *Important.* Make all near point calculations from patient's actual working distance.

ILLUSTRATIVE CASES

(1) Miss A., stenographer. Age 19, wearing R and L —1.

Acuity 6/6 with correction, 6/18 without. History of headaches. Tonicity at distance without correction Eso 1△, with correction 2△. Abduction, distance 8△. Recovery 6△. R and L —0·75 with 3△ base in each eye gave 6/6.

Cross cyl. near point test revealed latent hypermetropia +2. Prescribed for constant R and L —0·75 3△ base in each eye together with base in exercises.

Second correction R and L —0·50 with 3△ base in each eye = 6/6.

Third correction R and L △ —0·25 with 4△ base in each eye = 6/6.

Ordered glasses to be worn for near work only.

Present acuity —6/6 without lenses.

(2) *An early Myopia.* Child, age 10, complains of headache at school.

Visual acuity 6/9 with —0·5 and small cyl. 6/5.

Distance abduction 7△, recovery 3△.

Prescribed 1½△ base in for constant wear, which gave her after two weeks 6/6.

Seen one year afterwards. R and L 6/5 without glasses, 1 Exo. at distance, abduction as before.

(3) Child, already wearing R —0·50, L —0·50 with —0·37 hor., complains of headache. Small print looks "funny" with glasses. Thinks glasses are a great asset as she can see cinema pictures so well with them. In fact, refuses to leave them off.

Induced Eso by wearing lenses 1△.

Distance abduction 5△, recovery 3△.

Cross cylinder near point test seems to indicate latent hyperopia of 1D.

Gave her her present lenses with 1½△ base in each eye with +0·75 bifocal segments. To be worn at school, for all reading, and at cinema.

Relaxation exercises.

Most of the concave element has now been eliminated. 2△ base in prisms, each eye, now being worn.

As a final word, proper investigation of these seeming cases of myopia will enable the refractionist to earn the gratitude of his patient either by eliminating headaches without glasses, or alternatively if not entirely dispensing with their use to materially reduce the strength of those already being worn.

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AN INVESTIGATION AS TO THE NEED FOR "DROPS" OR CYCLOPLEGICS IN EYE EXAMINATIONS

Part One

Among the relatively small group of refractionists who habitually use a cycloplegic in their refractive work, we find that homatropine is the drug usually employed. We say the relatively small group, because of the total number of refractionists in this country, some seventy per cent are optometrists, who are so educated as refracting eye specialists as to enable them to do, with technical skill, eye examinations without resorting to the use of the drug. The remaining thirty per cent are oculists and many of these medical refractionists are also so trained as to enable them to perform eye refractions, also without resorting to the use of a cycloplegic.

And now as to this smaller group of eye examinations which are made upon eyes into which has been placed "drops" or what is more properly called cycloplegics. Just what cycloplegic is used? What is its effect upon the eyes into which it has been placed? And why is it used as it is by certain oculists in doing their refractive work?

As we have already said, the cycloplegic in greatest use in this country are gelatine ophthalmic discs containing 1/50 gr. each of 2% homatro-

pine hydrobromide and cocaine hydrochloride. The use of these discs, or the use of the same drug instilled into the eye in solution form, has in certain cases the property of inhibiting or reducing the accommodative amplitude as well as enlarging or causing a dilation of the pupil. In theory, at least, the users of the drug in their refractive work, do so to determine, if possible, the exact refractive status of the eye under observation with its focusing mechanism temporarily at rest. The enlargement of the pupil is of no value in refractive work. In fact, it becomes a very serious handicap in making an examination, but as it is impossible to therapeutically inhibit the muscles controlling accommodation without at the same time enlarging the pupil, this disadvantage is accepted as unavoidable and the work done in spite of the disadvantage.

It is therefore seen that the purpose of using a cycloplegic in refractive work is to reduce the accommodative amplitude to a point wherein the refractive status of the eye could be estimated or measured independent of the accommodative action of the ciliary muscle.

This in itself would perhaps be a laudable purpose and in some cases at least a worthwhile one—if it could be done. However, in actual clinical practice it is never accomplished. Today, no known drug will accomplish this purpose in a uniform manner in a majority of cases, and unless one can get a more or less uniform result from the use of a drug in at least the majority of patients upon which it is used, the findings gotten as the result of the use of the drug will lead to confusion. We say that no known drug will accomplish the purpose wished for by those now using a cycloplegic in refractive work, and in so doing we include the very powerful drug, atropine, which even when instilled into the eyes daily for a period of several weeks, still fails to produce clinically the uniform results which must be had if the resulting refractive findings can be relied upon. If this is true with atropine it at once becomes evident that it is even more true with the much less effective homatropine solution now generally used by those remaining refractionists who cling to the use of a cycloplegic in their refractive work.

Let us therefore study the clinical use of homatropine. The drug now in use here in this country by certain oculists in their refractive cases. Homatropine is a fast acting drug. It has to be fast to be used in routine clinical practice. Few patients are willing to be incapacitated for more than twenty-four hours for an eye examination and therefore whatever drug is used (if one must be used) in an effort to inhibit the accommodative powers of the eye, by in some way affecting the ciliary muscle, must needs be one that acts with some rapidity on the fibers of this muscle.

In actual practice the technique of using the drug follows the now outlined procedure. Two of the gelatine ophthalmic discs are placed in the palpebral fissure of each eye, and the patient is requested to keep his or her eyes closed for a period of five minutes. After a period of an hour

has elapsed the examination then proceeds in the usual manner. This first examination may or may not be followed by a post-examination, done on the following day after the effect of the drug has subsided.

Now we have said that the refractive findings gotten as a result of the use of a homatropine solution in an eye examination are of little if any value. This is certainly true scientifically as we will show later on in this paper. In fact, we contend that as far as the technique now in use with this homatropine solution, or with the gelatine ophthalmic discs of homatropine is concerned, the effect it has on the ciliary muscle is so variable and therefore so unreliable in its constancy of results that instead of getting truly usable findings the examiner is more often mis-led by the findings, and the final results of his entire examination procedure therefore suffers.

Before, however, going into the clinical experimental work upon which the foregoing statement will rest, let us first review some of the literature dealing with this subject. This literature divides itself into two general classifications. First, the subject as it is handled by those outstanding world-wide authorities who have proven themselves to be thinkers and scientists. Men who have done much to enrich the ocular fields of medicine, physiology, optometry, psychology and optics. The second, those many prolific writers, who have added much to our literature but little of it being original. Their works consisting of a repetition of what some other author has written, placed before their readers in a new but not original dress. In ocular fields, as in many others, the true thinker, the real scientist, the leader whose works prove to be of lasting value are in the minority. The gift of having the proper type of analytical mind for research and constructive original thinking is a rare gift and but seldom found.

A careful review of the literature in the fields of ophthalmology, physiology, psychology and general medicine discloses a complete lack of controlled experimentation in this field. Many dogmatic statements about the value of a cycloplegic are to be found. Also many statements as to the inadvisability of using "drops" in an ocular examination will also be found. Yet in all of these, the authors are but using their own clinical experience, or taking the word of some previous writer in whom they have confidence on this matter. In none of these, has the author taken upon himself the difficult task of running a series of controlled experiments to demonstrate, in a thoroughly scientific manner, just what the results of using a cycloplegic would really be. It seems almost unbelievable that in a subject as important as this, that not one medically trained person has bothered to really investigate the subject in a manner which would produce findings in such a controlled form as to be acceptable as scientific data.

However, irrespective of their value as scientific data, let us first review some of the statements by outstanding ophthalmologists who

seem in part or in whole to favor the refractive use of a cycloplegic.

A. Edward Davis, M.D., in his new work, MEDICAL TREATMENT OF CATARACT, F. A. Davis Co. (1937) says, "A thorough and complete examination of the eye should be made, under a mydriatic (Euphthalmine or Homatropine) in most patients above forty years of age."

W. A. Fisher, M.D., in his work, OPHTHALMOSCOPY, RETINOSCOPY AND REFRACTION, says, "Great care and adjustment is required in the use of cycloplegics, and while no positive rules can be laid down and each case must be considered on its own merits, the following suggestions as to their use will be found helpful. (1) All children under ten years of age should be refracted under a cycloplegic. All cases of astigmatism should be corrected in full but some of the sphere should be deducted. (2) All cases of strabismus should be refracted likewise, and as full correction as tolerated be prescribed. (3) Asthenopic patients who have not found relief with their manifest correction, should be similarly treated. All of the cylinder, and all of the manifest spherical, and part of the latent spherical is prescribed for constant wear. (4) If the manifest correction produces approximately normal vision in an asthenopic patient with subnormal vision, a cycloplegic will usually not be required. (5) Before using atropine in a middle adged patient, carefully consider the possibility of producing glaucoma in that particular case (by the use of the cycloplegic). (6) Cycloplegics are rarely, if ever, required in patients over forty years of age and never in those over fifty."

It will be noted that while both Davis and Fisher are in apparent agreement as to the use of a cycloplegic in certain eye cases, they are in complete disagreement as to the age levels of patients in which these drugs should be administered.

Sanford R. Gifford, M.D., author of the new OCULAR THERAPEUTICS, Lea & Febiger (1937), says, "The typical mydriatic, which is also a cycloplegic, is atropine. It is usually used as the sulphate, in 1 per cent solution. In strength instillation of 1 or 2 drops in the conjunctival sac of a normal person will produce maximal mydriasis within one hour and almost complete paralysis of accommodation in one to two hours. It has a prolonged affect, the cycloplegic and mydriasis being evident for ten to fourteen days. Hence, atropine is never to be used for the examination of the fundus in adults, and its use in refraction is usually reserved for children under ten years of age, and for exceptional cases in which complete cycloplegia cannot be obtained by substitutes whose action is less prolonged." He also says in comparing atropine and homatropine that "The majority of refractionists have found that equally accurate results are obtained in most cases by homatropine or other substitutes."

Gifford has this also to say on this matter: "Homatropine, used as the hydrobromide, is the substitute for atropine which has found its chief use in refraction. It acts in the same way as atropine but its effects

persist only 12 to 24 hours. A 2 per cent solution is usually employed." As he is the leading ophthalmologist in the field of ocular drugs and ocular therapeutics his views are of importance.

Charles H. May, M.D., in the Fourteenth Edition of his work on the DISEASES OF THE EYE, William Wood & Co. (1934) has this to say on the subject, "A cycloplegic is indicated in estimating refraction in all children and young adults up to 40, sometimes between the ages of 40 and 45, rarely between 45 and 50 if the previous examination has been unsatisfactory. Before using these agents (Atropine and Homatropine) in adults any suspicion of glaucoma must be excluded; after using them, eserine should be instilled to produce miosis before the patient departs."

Sir John Herbert Parsons, Ophthalmic Surgeon, in the eighth edition of his DISEASES OF THE EYE, Macmillan Co. (1936) Chapter XXIV, follows about the same line of reasoning as does May. They both suggest the use of a cycloplegic but offer no supporting evidence as to the value of the technique.

J. T. Maxwell, M.D., in his book, OUTLINE OF OCULAR REFRACTION has this to say regarding the use of a cycloplegic, "Cycloplegics are in common use among ophthalmologists for the purpose of relaxing the ciliary muscle in order that lens trials may be conducted without interference from accommodation. There are, however, instances in which the use of drugs may be impracticable."

James Thorington, M.D., in his book, "METHODS OF REFRACTION says, "A cycloplegic can be used to temporarily suspend the action of the ciliary muscle, or to put the eye in such a state of rest that all accommodative effort is for a time suspended while the static refraction is being estimated."

Stewart Duke-Elder, M.D., in his book, THE PRACTICE OF REFRACTION, Blakiston's Son & Co. (1935) has this to say about the use of a drug during an ocular refraction: "A state of paralysis of the ciliary muscle is called cycloplegia; it may be produced by drugs instilled into the conjunctival sac, such as atropine, homatropine and scopolamine, which are known as cycloplegic. These (drugs) also paralyze the sphincter muscle of the iris, causing a dilatation of the pupil; for this reason they are also called mydriatics." . . . "Both properties of cycloplegia and mydriasis are of service in the estimation of refractive errors. By paralyzing the ciliary muscle all accommodation can be abolished, and errors which before were latent are rendered manifest. The eye thus being put into a state of rest, its static refraction as opposed to its dynamic refraction can be estimated, and the disturbing influence of accommodation, can be abolished."

While a number of other outstanding medical writers could be quoted in a similar vein, enough have been presented here to round out the position taken by those oculists who seem to feel, as a result of

clinical evidence, that in some cases at least, refractions should be conducted with the aid of a cycloplegic. In none of the cases quoted, however, or in any of the other references which could have been added to those herein given, was there any evidence offered in the text to support the contention that something of value might come from the use of this procedure. To be sure, many say as does Duke-Elder, that by paralyzing the muscle having to do with accommodation one can then more easily determine the exact error of refraction, but at no point do any of these writers give supporting evidence that the technique they suggest will do this very thing.

Let us now turn our attention to those outstanding medical writers who are not in complete accord with the idea of using cycloplegics. At this point we will refer only to medical men and not give references from optometric literature, as it would be said that optometrists would naturally take the position that a cycloplegic was unnecessary as they were especially trained in their universities and colleges to refract without the use of the drug. Nor will we refer to the literature dealing with this subject as written by physicists, physiologists and psychologists, because these men treat the subject solely from the academic viewpoint and are not primarily engaged in the important work of eye examinations. Inasmuch as only some medical refractionists use the drug, it is of some importance to get the negative views of medical men regarding its use by their fellows.

M. Tscherning, M.D., in his great work, PHYSIOLOGIC OPTICS, page 88, says: "Dr. Wecker held decided views on the abuse of atropine in ophthalmic practice, and as far as its use for the determination of refraction is concerned, I am in perfect agreement with him."

L. K. Hirschberg, M.D., of the Johns Hopkins University, said: "Eyes can be examined much more satisfactorily without drops if specialists would only realize it. Many failures by the best oculists are attributed to the use of atropia and belladonna drops."

Doctors Norris and Oliver, of the University of Pennsylvania, said, in reference to the examinations of the refractive conditions of the eyes: "In all examinations avoid the use of drops, the examiner should learn to depend upon his own skill."

C. W. Talbot, M.D., Senior Ophthalmic Surgeon, Bellevue Hospital, New York, said: "A drug in eye examinations is not necessary unless the operator's knowledge is limited."

E. E. Blarrow, M.D., speaking before the Eleventh International Congress of Ophthalmology, said: "The determination of refractive errors with a mydratic is objectionable, troublesome and unnecessary."

Paul Romer, M.D., in his TEXT-BOOK OF OPHTHALMOLOGY says, "It is wrong to fit glasses while the pupil is dilated with a drug."

Dr. Swan M. Burnett, Professor of Ophthalmology, Georgetown

University, said: "What is needed is skill, not atropine or any poisonous drugs."

Drs. Copeland and Ibershoff, in their TEXT-BOOK OF REFRACTION: "The more skilled the refractionist the less will he depend upon drugs."

William George Sym, M.D., F.R.C.S.E., Ophthalmic Surgeon, Edinburgh Royal Infirmary, Lecturer on Diseases of the Eye in the University of Edinburgh, in his text-book for students and practitioners, says, page 72: "The argument in favor of atropine falls to the ground. . . . I do not admit that one does not discover the total hypermetropia without a mydriatic. . . . My practice, founded upon the satisfactory experience, is not to administer a mydriatic."

Dr. Herman Snelling, Ophthalmic Surgeon, Netherland Hospital, Utrecht, Holland: "Any mydriatic solution instilled in the conjunctival sac, may produce general disturbances which sometimes assume a most alarming character and may even cause the death of the patient."

Mr. Harrison Butler, M.A., M.D., M.R.C.S., etc., England, a leading authority on ophthalmic subjects, before the Ophthalmological Society of the United Kingdom in 1922 said: "I was encouraged to give up cycloplegics by my friend, Dr. Devereux Marshall, who told me that he regarded them as unnecessary. . . . The amount of confusion caused by a dilated pupil, where there is an error of refraction is extraordinary. I can be more accurate with a moderate-sized pupil than with a dilated one. Many children are frightened by the instillation of drops, and the cycloplegic defeats its own end. There is one vital objection to a cycloplegic: one has to guess how much to allow for the drug in ordering glasses. . . . In two of my hospitals I now rarely use a cycloplegic. . . . In conclusion, I suggest that the refraction without a cycloplegic is as accurate as that with one, if only correct methods are employed and if sufficient experience and skill are at the command of the refractionist."

And to quote again from Duke-Elder, who has already been mentioned as having something good to say of this practice, we now find him in another part of his monumental work on refraction saying: "The use of these drugs, however, is not without disadvantages. The eye with its accommodation paralyzed is a pathological eye, and cannot be legitimately compared with the normal organ. The dilation of the pupil alters considerably the optical properties of its refractive apparatus, and intensifies the physical errors due to aberration through the peripheral parts of the refractive media. Further, the periphery of the pupillary aperture frequently has a refraction quite different from the central part, which is alone employed in the normal circumstances of life. Moreover, when the ciliary muscle is paralyzed, the lens capsule is in a considerable state of tension, but when the muscle once more becomes active, it allows a relaxation of the capsule, and the lens becomes more spherical and its anterior surface assumes a hyperbolic shape." He adds further on, "To

correct a minute error (of refraction) which is not associated with definitely incriminating symptoms, especially when it is measured in the pathological condition of cycloplegia and transposed to the eye in its normal dynamic state, and when it is further warped by the optical defects inseparably associated with the fitting of glasses, is to misinterpret completely the whole economy of living organisms." Coming as this does from the greatest living British oculist who has just been knighted, this is a strong statement.

And last, according to Morris, writing in the DIOPTRIC BULLETIN, Vol. XXX, No. 6, pp. 306-307, who quotes the outstanding authority on anatomy, neurology and brain disease, the famous Dr. E. A. Spitzka, Professor of Anatomy at the Jefferson Medical College as saying, "When an individual's vision becomes impaired, I would rather have him go to an optometrist. As an active specialist in this field he acquires a special aptitude for the manipulation of instruments and the recognition of every abnormality which only a few medical practitioners can enjoy. In the majority of cases only correcting glasses are needed. In the small minority, in which a diseased condition exists, the optometrist can be relied upon to recognize the pathologic state, and send the patient to a suitable medical practitioner. I fail to see where there should be any conflict between optometry and medicine."

Here again, a number of additional medical authorities could be quoted, but enough have been mentioned to rather clearly indicate that by no means all oculists are in anything like agreement on the need for the cycloplegic, to say nothing of its use. It is well here to remember, however, that in these references from medical literature just quoted, in which the author was either indifferent towards or actually opposed to the use of "drops," here again no supporting evidence is given for the stand they take. As in the case of those oculists who seemed to regard the use of a cycloplegic with favor, those holding the latter mentioned negative opinions seemed to base them, not on scientific factual evidence, but rather upon the opinions of friends or on a more or less unsatisfactory clinical experience with the drug. And clinical experience, because of the necessary number of uncontrolled variables that enter into a clinical practice, is not admissable as evidence in the scientific world, as is well known to all research workers.

The men just quoted are all of some considerable standing in the field of ophthalmology. Each of them has had a part in developing ocular science to the present high place it now occupies. Many additional references from other men of similar outstanding position could be given, to say nothing of the mass of material on this subject which could be quoted from among the writings of the lesser authors in this field. Those already presented, however, are sufficient to indicate that among the leaders in the field of ophthalmology there is no agreement on the need for the use of a cycloplegic in ocular refractive work. Not only do these

men who occupy the front rank in their profession find it impossible to agree in this matter, they too fail in their handling of the subject to give it the attention it should have had, inasmuch as they at no time have attempted to review the matter in the light of making a scientific analysis of the subject from the standpoint of a thorough going study of the effect of a cycloplegic when used in a given number of controlled cases, each case handled in such a way as to control the usual variables, as normally found in clinical practice.

It therefore remained for Edwin Forbes Tait, Ph.D., assisted by F. W. Sinn, to devote the time and effort necessary to make a controlled investigation of the entire matter. Tait, for many years a teacher of ocular refraction, was most qualified to conduct this type of research as he was then and is now, one of the foremost educators in the field of ocular refraction. A man, because of his training, and contacts with various clinics, who had become thoroughly familiar with the practice of refraction both from the standpoint of a cycloplegic as well as one in which the non-cycloplegic techniques are used. During the twenty years in which he has observed and worked on refractive problems, and also subjected them to experimental attack in the physiological optics laboratory, he became convinced that few of those engaged in the controversy over the need for the cycloplegic had any scientifically sound basis for their opinions.

The reasons, according to Tait, usually advanced for either the use or the non-use of cycloplegics, were of a type unacceptable to the physiologist, and also indeed, to an impartial observer and seemed to have more emotional than scientific content. The importance of the subject in the development of applied physiological optics made an experimental attack on the problem desirable. In view of the very uncertain mode of action of the ciliary muscle in bringing about accommodation and the impossibility, therefore, of devising direct experimental methods, the problem was approached entirely from the controlled clinical viewpoint with the results, however, interpreted in the light of modern physiological concepts.

Tait, writing in the AMERICAN JOURNAL OF OPTOMETRY, April, 1936, found as did the writer, that a careful review of the literature disclosed the lack of controlled experimentation in this field. Many statements and opinions on the subject, beginning with that of Donders, are on record, as the present writer has also pointed out, but unfortunately none are acceptable as scientific data from the physiological viewpoint, whatever their value may be from the clinical. Donders in his work, ACCOMMODATION AND REFRACTION OF THE EYE, London, 1864, pp. 584-590, observed that with the presistent use of atropine sulphate there was a very prompt dilation of the pupil and shortly thereafter a rather complete disappearance of the amplitude of accommodation, both of which phenomena are too familiar to require any additional consideration here.

Later on, Landolt in his REFRACTION AND ACCOMMODATION OF THE EYE, Edinburgh, 1886, p. 560, adopted Donders' viewpoint and methods without serious question and advocated the use of cycloplegics in certain types of refractive cases, apparently with the idea that the inhibition of the accommodative amplitude would be helpful in refraction procedure. In other words, Donders in the early eighteen-sixties discovered the phenomena and twenty years later on Landolt, without any experimental work on his part, and in an off hand sort of way, suggests in his writings that this discovery of Donders might possibly be of value in refractive work. Thus the use of cycloplegics, only tentatively suggested by Landolt as a possible aid in certain cases, became among certain refractionists quite general, and led, quite naturally, to the apparently unjustified conclusion on the part of those who used only this method of refraction, that this sort of work could not be done properly without the drug.

The validity of this conclusion was unquestioned among this group, for many years and no further experimental attack on the problem was made until very recently, in spite of the fact that considerable difficulty was frequently encountered in the prescribing of proper lenses and the percentage of inaccuracies with subsequent changes was fairly high even when the work was done by presumably skilled men. Of this the clinical literature gives abundant evidence. An honest facing of these facts has led, in recent years, to considerable speculation and some investigative work directed toward a better understanding of the fundamentals of cycloplegic refraction. In 1932 Prangen in a paper entitled "What Constitutes Satisfactory Cycloplegia?" AMERICAN JOURNAL OF OPHTHALMOLOGY, Vol. 14, pp. 665-671, reported a clinical study of 63 cases, in which he observed that with the use of homatropine, a complete inhibition of accommodative amplitude was not obtained. He concluded that the residual accommodation after a cycloplegic has been administered should not be more than two or three diopters, for proper results to be obtained in refraction.

Prangen apparently assumed that the ciliary tonus was inhibited to an extent roughly proportional to the decrease in the accommodative amplitude and that sufficient of the drug should be used to reduce the amplitude to the above optimum value.

Bothman in a paper entitled "Homatropine and Atropine Cycloplegia," ARCHIVES OF OPHTHALMOLOGY, 1932, Vol. 7, March, pp. 389-98, in studying the comparative effects of homatropine and atropine cycloplegia found that ½ diopter was the average difference of results in hyperopic eyes although individual cases showed differences up to and even greater than two diopters while individuals with myopia or mixed astigmia may present still greater differences. He apparently takes the results obtained by atropinization as the criteria of accuracy although the report concerns itself only with the differences in the effect of the

two drugs. Although the results are not wholly consistent it is notable that more ciliary inhibition was obtained with artopine than with homatropine. Apparently, in this study, no effort was made to control other variables such as illumination, pupillary size, etc., and the precise method of judging differences is not discussed.

Now according to Tait, Landolt considered that the principal value of the cycloplegic was in its effect upon "tonic" and "clonic" accommodative cramps or spasms. The modern refractionist who uses cycloplegics usually justifies his procedure by stating that the drug "relaxes the accommodation" by inhibiting the contraction of the ciliary muscle and thus eliminating the power of accommodation. This viewpoint, however, is manifestly faulty unless the reduction of the amplitude of accommodative also reduces or eliminates the accommodative effect of the normal tonus or postural muscular activity of the ciliary muscle. Clinical experience constantly demonstrates that the accommodative amplitude above the tonic or manifest level is never used during a refraction procedure if care is first taken to make the patient artificially myopic with suitable lenses.

The normal ciliary muscle undoubtedly possesses, as do all other live muscles, a tonus which manifests itself in this particular instance as a small but constant amount of accommodation, the effect of which was termed latent hyperopia by many who have discussed its effects but failed to understand its physiological nature. It is undoubtedly this constant or tonic accommodation, which when increased either by excessive tonic innervation or by actual metabolic changes in the muscle itself, gives rise to the greater levels of tonic accommodation usually considered as muscular cramps or spasms.

When analyzed from Tait's standpoint, therefore, "clonic" and "tonic" spasms or "cramps" resolve themselves into the end effect of variations in ciliary muscle tonus. Clinical experience with prolonged atropinization has shown rather definitely that in many cases the level of tonic accommodation is varied considerably as long as the drug is effective but that when the influence of the drug wears away the tonus returns to approximately its former level. In the use of cycloplegics for refraction purposes therefore, the important factor is not the extent to which the accommodative amplitude is inhibited but the way and the extent to which the normal ciliary tonus or a ciliary hypertonus is affected.

While this is a perfectly sound viewpoint, justified by common experience in clinical application, as well as one physiologically acceptable, it has not been recognized or utilized by previous workers. No accuracy in the interpretation of results under cycloplegia can be obtained, therefore, unless there is a more precise knowledge of its effects upon the tonic or hypertonic accommodation. With these facts in mind Tait, assisted by Sinn, determined to investigate the action of homatropine with respect to the way in which it might affect any variation in the

normal ciliary muscle tonus, and thus arrive indirectly at the manner in which hypertonic ciliary conditions may be affected by the employment of the drug.

In an investigation of this character it is necessary to eliminate, as far as possible, variable factors other than the ones to be determined. Therefore the apparatus and procedure used by Tait and Sinn were carefully designed with that purpose in mind. For both series of tests, those with and those without cycloplegics, the same apparatus and material were used. The apparatus consisted of a DeZeng phorometer with an attached near point rod and a standard illuminated test chart placed at the usual 6 meter distance and the usual refracting room equipment, test case and luminous skiascope. For near fixation a 3 centimeter black letter on a 13 centimeter white card was fixed 1/3 meter distance in the movable card holder on the near point rod. The illumination of the room and the distance and near test chart was kept at a constant level throughout the experiment. In order to limit the aberrations resulting from the variability of the pupillary aperture due to the mydriatic effect of the cycloplegic a series of pupillary discs ranging in ½ mm. steps from 2 to 6 mm., was employed. In order to eliminate any variations arising from the difficulty in administering exact amounts of the drug in solution form, gelatine ophthalmic discs containing 1/50 gr. each of 2% homatropine hydrobromide and cocaine hydrochloride were used in all cases.

The subjects selected by Tait for this experiment were college students, between the ages of 18 and 23, all of whom were previously corrected for any existing ametropia and had no marked accommodation or convergence anomalies or history of asthenopia. There were 75 of these subjects.

The experimental technique employed by Tait and Sinn in compiling their data was as follows: (1) The apparent diameter of the subject's pupils was first approximated in low illumination. A pupillary disc of ½ mm. less than the diameter was placed in the phorometer before each eye, and so centered that each pupil was concentric with the disc when fixing on the test object. (2) A static skiametric test was then made, with the observer at 20 inches and the subject's attention fixed at 20 feet. (3) The monocular visual acuity was noted with the skiametric finding in the phorometer. (4) A careful subjective fogging test was made. (5) The monocular visual acuity recorded with the subjective findings in place. (6) Two gelatine ophthalmic discs of homatropine were placed in the palpebral fissure of each eye, and the subject was instructed to close lids and keep them closed for five minutes. An hour was then allowed to pass. (7) A static skiametric test was again made, with the subject wearing the same pupillary discs. (8) The visual acuity was again noted, with the static findings in place. (9) A subjective fogging test was made. (10) The visual acuity was again recorded, this

time with the subjective findings in place. (11) The monocular positive relative amplitude of accommodation under a cycloplegia was then taken. This was done as follows: The subject with the cycloplegic subjective correction in place was made artificially myopic for 20 minutes by the addition of a +2 D. Sphere. The near point card was moved in slowly until the subject reported a slightly perceptible blur of the fixation letters. The amplitude was calculated by taking the dioptric difference between 20 inches and the near point observation and the value could be considered as reasonably accurate within the spread of the clinical error.

Table 1 shows the result of this experimental work done by Tait and Sinn. In this table the effects of the homatropine are shown as found by comparing the cycloplegic refraction with the non-cycloplegic refraction results, the difference between them being the effect of the cycloplegic on the ciliary muscle tonus. This comparison was made in the 150 eyes of the 75 subjects examined in this study. It will be noted that the effect ranged from a relaxation of 1.75 D. to a stimulation of 0.75 D. Assuming a possible clinical error of 0.25 D. we find that the homatropine had no effect on the ciliary tonic level in 70% of the subjects. In 21% there was a ciliary relaxation, to be considered as a tonic relaxation. Other atypical cases, amounting to 9% of the total showed an increase of tonus instead of a lessening. Table 2 shows the residual amplitude of accommodation relative to the conditions of the test under cycloplegia. The amounts found in the whole group ranged from 0.25 D. to 8.00 D. with 79% of the cases, showing from 1D. to 3 D.

TABLE 1.

Type	Amt. in Diopters	No. of Cases	% of Cases
Relaxation	1.75	2	1.3%
Relaxation	1.50	1	0.65%
Relaxation	1.00	3	2.0%
Relaxation	0.75	8	5.3%
Relaxation	0.50	15	10.0%
Relaxation	0.25	29	19.0%
	0.00	54	36.0%
Stimulation	0.25	25	16.6%
Stimulation	0.50	11	7.3%
Stimulation	0.75	2	1.3%

TABLE 2.

Type	No. of Cases	% of Cases
Relaxation of Both	25	33.3%
Stimulation of Both	11	14.6%
No Effect of Both	17	22.7%
One Stimulation—One Relaxation	2	2.8%
One Stimulation—One No Effect	13	17.3%
One Relaxation—One No Effect	7	9.3%

It is very important, and must here be pointed out, that the method used in this investigation by Tait and Sinn would record only the variations in ciliary tonus regardless of the accuracy of the subject's refractive correction so that the results are not invalidated or in any way affected by possible residual refractive errors.

It is also evident from a careful study of the data presented by Tait that the physiological effect of the use of homatropine, at least in the quantities used, cannot be predicted with any certainty.

The effect as Tait points out, upon any given subject, may be either relaxation or stimulation of the basic tonus of the ciliary muscle or no reaction at all. In the interpretation and utilization of data obtained under this type of cycloplegia these possibilities must be considered and the range of possible clinical error fully recognized. And as the writer has already pointed out, this fact is not, we fear, recognized, by many oculists who now employ the cycloplegic as herein outlined in their practices from day to day.

As Tait has shown in his experimental work which we have just reviewed, the variations, when a cycloplegic is used in the tonus of the ciliary muscles are so great as to make whatever findings as result from the examination techniques of very questionable value indeed. In fact, these variations would tend to confuse the examiner rather than to assist him as it is evident that there is no known predictable reaction which results from the use of the cycloplegic. When as Tait points out the drug actually stimulates accommodation in some cases instead of repressing or inhibiting it, it becomes obvious that only confusion in refractive findings can result from its use, as the examiner has no method of knowing just what result he is getting from the use of the drug in any one particular case. Of three cases examined in one day the first may get the desired ciliary relaxation, the next may actually be one of those cases wherein the drug stimulates the ciliary instead of inhibiting it while in the third case, the drug may have no effect upon the accommodation at all. If the same interpretation is placed on the results in all three cases, it is also obvious that in at least two of them the final result will be far from correct.

If the results of Tait's experimental work in the physiological optics laboratory are correct, and the writer has carefully reviewed the work done by these investigators, and feels that it is correct, his findings leave those oculists who persist in the use of a cycloplegic entirely without any scientific basis for their so doing.

The results of Tait's experimental work account in a great measure, we believe, for the apparent disagreement among oculists as to the value of the cycloplegic in refractive work. Many who no longer use the drug as a routine clinical procedure, have discarded it because of the variability of the findings and because of the utter lack of uniformity of response on the part of the ciliary muscle after the drug has been instilled. This,

we believe, to be particularly true when these men have also observed the fact that the great majority of ocular examinations are made, and made successfully by refractionists who as a rule do satisfactory work without resorting to the use of the drug, and its inherent disadvantages.

Summary of Part One

1. But a small percentage of refractionists habitually use a cycloplegic in their refractive work.

2. The cycloplegic usually used is homatropine.

3. A review of medical literature shows that oculists are divided in their opinions regarding the value of a cycloplegic in refractive work.

4. It is shown that while some oculists use homatropine as a cycloplegic in refractive work, that no controlled investigations of its action upon the ciliary muscle has been made by them.

5. It is further shown that those oculists who favor the use of a cycloplegic do so only on the basis of the refractive reactions as secured in clinical practice, and that these findings are not to be relied upon.

6. Research work by Tait and Sinn on the effect of homatropine on the ciliary muscle tonus is reviewed, and it is shown that the clinical use of a homatropine in refractive cases is of no value because, (a) The important factor in refraction procedure as far as accommodation is concerned is the variability of tonic, or postural activity of the ciliary muscle. The amplitude of accommodation has no necessary relationship to the level of the ciliary tonus. (b) With homatropine, used as has been outlined, there is no definitely predictable ciliary response as far as can be determined in the research work done under controlled conditions to study this matter. (c) As there is no constant or predictable effect on normal ciliary tonus it is probable that there is similarly no predictable effect in ciliary hypertonus. (d) That the limits of variability in the refractive findings in using homatropine are from 1.50 D. of relaxation to 0.75 D. of stimulation, and (e) that these limits are so great as to make refractive work done within them of very doubtful character.

7. Cycloplegics or "drops" therefore, should not be used in refractive work.

Part Two

CASE REPORTS IN WHICH CLINICAL EVIDENCE IS PRESENTED TO SHOW THAT THE USE OF "DROPS" OR CYCLOPLEGICS IS UNSATISFACTORY IN EYE EXAMINATIONS

As we have previously shown, the technique of using "drops" or what are more properly called cycloplegics in eye examinations is unscientific and therefore should be discontinued by all doing this work. The evidence presented clearly indicates that the use of cycloplegics makes the examination procedure more difficult because of aberrations which result from the dilatation of the pupil. It also proves that the use

of a cycloplegic makes the refractive findings more unreliable because of the complete lack of uniform response on the part of the ciliary muscle fibers to the drug employed.

These are facts that have been known for years. In reality the technical side of the profession of optometry was founded on this belief. Thirty-seven years ago, when the first law governing the profession of optometry was passed, those early optometrists who assisted in writing the act, requested that they as refracting eye specialists be enabled to examine eyes and prescribe for visual abnormalities. Then as now optometrists were chiefly interested in correcting for and diagnosing various errors of refraction and these forerunners of present day optometrists realized that there was no need for the use of a cycloplegic in refractive work. With this in mind, many of these early pieces of optometric legislation mentioned the fact that no "drugs" be used by persons licensed by the act. This was not done, as some present day oculists would have us believe, because of a lack of refractive knowledge on the part of the optometrist of that early period, but rather to prevent those pioneer refractionists from attempting to treat ocular diseases by therapeutical means, a province which they all agreed belonged to medically trained men.

As we have said, the fact that a cycloplegic was unnecessary in ocular refractive work has been known in optometric circles for years, and today there is no disposition on the part of any optometrist to use the drug. Trained as they are in their universities and colleges to do proper diagnostic work without the drug, nothing could induce them to give up their present day satisfactory and scientific examination procedures for the more unreliable and haphazard guess work which results from the use of a cycloplegic in eye examinations. While all optometrists, and as we have shown many oculists, were confident that the non-cycloplegic refractive procedures and tests were based upon a scientific background of factual information, and while these refractionists knew that the results obtained by others, when a cycloplegic was used were very apt to be faulty, it was not until Tait and Sinn conducted their researches into the value of a cycloplegic in refractive work that scientific evidence was presented to prove to members of both professions that the use of homatropine in eye examinations was of no value.

It has been shown therefore that there is no scientific basis for the use of "drops" or cycloplegics in eye examinations. It has also been shown that the use of homatropine, the drug usually employed by those oculists who still cling to this practice, will lead to such variable findings that only confusion will result from its use, when used in eye examinations. It would seem that this disposes of the practice from the scientific viewpoint. Let us now turn our attention to the clinical or non-scientific phase of this work. Let us review the literature and see from this just what result the use of the drug produces when studied from the purely

clinical aspect. While we have said that clinical evidence is of no scientific value because of the large number of uncontrolled variables which are inherent in any clinical practice, the clinical evidence is nevertheless of interest because it, in a large measure, substantiates the scientific evidence produced by Tait and Sinn, and it also indicates that the percentage of error of those who use the drug in attempting to diagnose errors of refraction is very high.

Foster, a dispensing optician reports the following case in THE OPTICIAN, Nov. 30, 1928, pp. 263-264. A patient brought him a prescription that had been written by an oculist asking him to make up the necessary glasses. This was done. In about three weeks the patient found it necessary to return to the oculist complaining that he was not as yet able to see clearly with one eye and that he was more uncomfortable in his new glasses then he was in his former pair. The oculist reexamined him and told him that his glasses had been made stronger than prescribed, but it so happened that owing to a change in his sight, since he was first tested, the glasses answered quite well now, and that he would very soon see clearly and comfortably. He sent a note to Foster saying, "Both lenses have been made stronger by 0.5 than ordered, but for the present they can remain." Foster checked the glasses and the original prescription and found the glasses to be made as originally ordered.

In about another three weeks the patient again returned to the oculist but found him away on a vacation so he had to wait two additional weeks until he returned. Upon going back for the fourth time he was informed that he would be seen, although he was not entitled to more than one examination for the usual fee. He informed the oculist that he had made no progress with the glasses, one eye still being very blurred, and that he was just as uncomfortable as ever. He was again examined, after which he was told to take the glasses back to Foster and get him to make one lens weaker, but the other could remain as it was. The note read: "The right lens can remain, but the left lens must be made weaker by 0.5."

The patient remarked to Foster that it appeared very strange to him that if the glasses were wrong as the oculist claimed that only one lens should be changed, while if the glasses were made according to the original prescription as claimed by Foster, that he was naturally beginning to lose confidence in the oculist. Foster again assured the patient that the glasses were made according to the original prescription and that he could not undertake to change them without additional payment. After some discussion the patient decided to consult another oculist who prescribed a correction 0.75 weaker than was prescribed by the first oculist. The second oculist verified the fact that the original prescription had been filled correctly by Foster; who says: "Thus it is found that although three examinations were made, there was an entire failure to refract the

case correctly, and furthermore, an inability (on the part of the first oculist) to even verify a pair of glasses made to his own prescription. In conclusion I feel (that this type of examination procedure) is getting worse and is fast becoming a fraud and a scandal."

This type of thing is commented on editorially in the same publication, December 7, 1928. The editorial which is short, reads as follows: "Many strange optical prescriptions of medical men have been forwarded to us during the past few days. Some have been published. We are impressed by the fact that in some cases, these peculiar prescriptions betray their writer's ignorance of comparatively elementary optical principles. Some, again, betray carelessness. For example, lenses have been transposed but the cylinder axis has been incorrectly recorded. In one case the axis of a cylinder in the patient's right eye was written 120° and noted 120° on the axis diagram, but should have read 60°. This kind of work is bad, and we are concerned by the tendency of certain medical men (who had been previously referred to as users of cycloplegics) to throw the onus of their errors on to the (dispensing) optician. We have in mind the particular instance when an oculist discovering that he had written a prescription wrongly, informed the patient that the optician had dispensed the wrong lenses. The slur was unnecessary and unfair, but we fear that the practice is unfortunately popular with a few ophthalmic specialists. This is only one . . . of many reasons why refraction work should not be delegated exclusively to (medical) doctors."

In the same journal, June 30, 1933, p. 333, we read the report of a patient who had been examined by a well known oculist who had given her the following prescription:

O.D. +2.50 D.Sph. ⊃ +1.00 D.Cyl. axis 90°.
O.S. +3.50 D.Sph.

A short time later on, this patient was examined by another well known oculist who prescribed as follows:

O.D. +1.75 D.Sph. ⊃ +1.50 D.Cyl. axis 95°.
O.S. +3.00 D.Cyl. axis 80°.

Strangely enough, comments the writer, the patient, a young woman of 28 years, seemed as comfortable with one correction as she did with the other, although obviously both could not be correct as the difference in each eye is considerable.

Discrepancies of the kind just referred to are explained by H. B. Marton, in a paper entitled The Treatment of Strabismus, THE OPTICIAN, Nov. 3, 1933, pp. 193-197. Marton says: "The use of a cycloplegic is an old and well tried means of unlocking the cramped ciliary muscle, but it is a fact of experience that 'cycloplegia' does not reveal the whole of a defect and that some further portion of the ametropia can be coaxed out if we will go about the task in the right fashion." Here is a well known writer on ocular matters; a man who has used

cycloplegics off and on for years, who admits, through his clinical experience that the results of the use of "drops" does lead to findings that cannot be wholly relied upon.

E. Moevius, in the June 22, 1934 issue of THE OPTICIAN has this to say on this same subject, "Judging by the correspondence appearing from time to time in your journal, it is evident that there are still a number of refractionists who believe that a cycloplegic is necessary in certain cases to obtain the exact correction of the ametropia in a pair of eyes. Seeing this is so, it becomes necessary to restate certain known facts relating to the effect that cycloplegics have on eyes when used for sight testing, and the danger to some patients of after-effects damaging their eyes, even though it is claimed that a new drug has been discovered free of this danger. Insofar as the eye muscles are concerned, a cycloplegic makes the living eye practically a dead eye for the time being, and while in this condition two refractive errors occur: More refraction than normal and the extra peripheral area of the dilated pupil may be found to have a different refraction than the smaller area of the pupil in its normal state. To the refraction found must be deducted 0.50 D to 1.00 D as it varies in different patients. The occurrence of these two errors makes it (refraction with "drops") guess work, and on this account the use of cycloplegics for sight-testing ought to be relegated into the limbo of exploded ideas. The claim that only a cycloplegic can disclose pseudo-myopia is no longer true, as it can be discovered by dynamic retinoscopy; and by the great improvements made in luminous retinoscopes, eyes with very small pupils can be refracted with but little difficulty, and further, with improved ophthalmoscopes, abnormal conditions can be easily noted."

And now let us review the report of a case submitted by Edward Jackson, considered by some, the Dean of American oculists; a man who has championed the use of cycloplegics for some time past. In an article appearing in THE REFRACTIONIST, July 16, 1931, p. 270, he is quoted as follows: "Jackson gives the case of the man aged sixty, apparently in good health, who came to him about his poor sight, after consulting in the last year six oculists in three different states. These men were all members of the American Medical Association, one of them a former chairman of the Section on Ophthalmology. The patient was much distressed by the opinion of one of his advisers that his poor sight was due to a vascular lesion for which he should have prolonged treatment, and that the result would be doubtful. He had glasses given to him by two oculists, the last being as follows:

O.D. +0.25 D.Sph. ⊂ +0.37 D.cyl. axis 180°

Add +2.50 D.Sph. for reading.

Jackson diagnosed the case as one of cataract and operated on his right eye. An examination with the ophthalmometer after the operation showed corneal astigmatism of 9.00 D.+ , the axis being 7°. Jackson

found that the following correction gave him a visual acuity of 0.9 for distance and enabled him to read successfully:

O.D. +5.00 D.Sph. ⌒ —8.00 D.cyl. axis 87°

for distance, and the following correction for reading:

O.D. +8.00 D.Cyl. axis 177°.

Jackson is quoted as saying: 'With these he went home as happy as he could have been after a successful cataract operation'." Here is clearly a case of mistaken diagnosis, reported by one of the outstanding oculists of this country and according to him, referring to several other leaders in this field.

G. H. Aronsfeld in a lengthy case report appearing in THE REFRACTIONIST, April 16, 1929, p. 152, presents a case of a boy, age 3-5/6 years of age. This patient was refracted under a cycloplegic about 8 months before coming to him. The patient had a slight squint. The left eye turned in more than the right. The oculist who had refracted him had prescribed a pair of +2.00 D.Sph. for constant use. These glasses he had worn regularly with no improvement noticeable by his parents, who then brought him to Aronsfeld. Without using a cycloplegic, Aronsfeld found the case accepting a pair of +4.50 D.Sph. which he also prescribed for constant use, along with some simple orthoptic muscular treatment. The case progressed to an uneventful recovery. Aronsfeld here presents a typical case of under-correction as the result of using a cycloplegic in an eye examination. This, however, being the very thing the cycloplegic is supposed to prevent if we can believe those who advocate its use. This type of case is quite common as many optometrists will verify who have had to change corrections which had been previously prescribed for patients under the effect of cycloplegics by oculists who were using the drug.

This fact is further emphasized by a physician who in a special report, THE REFRACTIONIST, August 16, 1928, p. 308, dealing with a case of a young man who accepted at least +3.50 D.Sph. during an eye examination in which no drug was used, and who in a subsequent examination, a week or so later on, accepted only about +1.50 D.Sph. during an examination in which homatropine was instilled into his eyes. The writer concludes by saying: "Not infrequently has this paradoxical result happened in my practice, and I have long been of the opinion that homatropine is undependable." This is just another of the opinions of an oculist who has used the drug and who is losing faith in its effectiveness.

L. A. Swann presents a case in which the patient had been overcorrected because of the inaccuracies resulting from the use of a cycloplegic. The report appears in THE REFRACTIONIST, December 16, 1933, pp. 424-425. The patient, a young man, on leaving school, wished to enter the postal service but feared the eye test as his left eye was defective. His parents sent him to an oculist for a refraction and homatropine was

used. The following correction was given him for constant use:

O.D. Plano.

O.S. +2.50 D.Sph. ⊃ +0.75 D.Cyl. axis 90°.

This lens for the left eye gave him a visual acuity of 7/24 and he failed to pass the visual test as required by the postal service. Swann without resorting to the use of a cycloplegic examined him and prescribed the following correction:

O.D. Plano.

O.S. +2.00 D.Sph. ⊃ +1.50 D.Cyl. axis 85°.

This last correction gave him a visual acuity of 7/12 and an additional post office test has now been arranged. Swann says in closing: "This case indicates first, that to use homatropine in every case is antiquated and can hardly ever produce a satisfactory result in the average case. Such a routine method shows ignorance, and often creates less vision, through the prescription of too strong lenses than would be present without any lenses at all . . . as a routine measure it is ridiculous and it is amazing to find that some oculists still adhere to this practice which has been proved up to the hilt to be not only unnecessary but inaccurate."

The cases mentioned, while proving nothing in themselves, do indicate, however, that the mere use of a cycloplegic is not a guarantee of a successful refraction. In fact, many, many cases could be reported showing errors in work done by those who use the drug and by those who do not refract with it, yet these cases would do little else but to indicate that the cycloplegic is not the factor for success in eye examining work that some examiners would have the public believe. In the light of real scientific evidence already presented against the use of homatropine in refractive work, the cases just presented do of course, substantiate the contention that the cycloplegic when used tends to confuse rather than clarify the results of the tests normally employed to examine the eye. These case reports do show as well as it is possible to show anything from clinical evidence that the cycloplegic does not make the work easier or more accurate than similar work done by either optometrists or oculists trained to examine the eye without resorting to the use of "drops."

These case reports are not submitted as scientific evidence. Cases refracted in private practice with the inevitable innumerable variables which would naturally occur from one refracting room to another, the work being done under varying conditions and given various interpretations by different examiners make this sort of thing as unscientific a sort of evidence as it would be possible to secure. Yet these case reports do have some slight standing as clinical evidence, inasmuch as patients were worked upon in the usual and customary manner and judged the results of the work in the typical manner of patients judging the results of any piece of health work—the patient reaction as to what was prescribed for him. In these case reports, the patients found the glasses

prescribed while under the effects of homatropine to be either too strong or too weak for comfortable use. In other words the work was unsatisfactory. Hundreds of similar reports could be submitted. These same cases reported satisfaction after the examinations had been remade without using the cycloplegic and the prescription altered to an apparently correct finding.

Up to the present point in this investigation, nothing has been said on the two other important phases of this question. Those portions of this subject that have to do, first, with the personal inconvenience that patients are subjected to when "drops" or cycloplegics are used, and second, the latent yet ever present danger to the patients eyes and general health that exists whenever atropine or homatropine is instilled into the palpebral fissure of an eye. Both of these subjects are of importance to the public and to the professions doing eye examining work and will be dealt with in some considerable detail in a later paper. In this presentation as in Part One, the subject has been treated only from the standpoint of the value of the cycloplegic as a part of an eye examination. Even had the findings supported the contention, which they have failed to do, that a cycloplegic has some value as an aid in making an eye examination more accurate, its use would still be of doubtful value in view of the inconvenience and danger involved when the drug is used in the eye as it is today. However, these phases of the subject will be left in this paper, with only this brief mention, and will be dealt with in detail at a later time.

This is true also of that portion of the subject having to do with the use of homatropine as a mydriatic instead of a cycloplegic. Here of course there may be some advantage in its use, as somewhat more of the fundus can obviously be viewed with ease, when the drug is used than without. Yet the ease with which this same fundus can still be viewed through the normal sized pupil, using only a modern electrical ophthalmoscope makes the routine value of this mydriatic technique questionable when the foregoing inconvenience and danger are also taken into consideration. This point will also be considered in some detail at a later period.

Conclusion

1. It has been shown that there is no agreement among medically trained refractionists as to the value of using "drops" or what are more properly called cycloplegics in eye examinations. Many oculists use them, and many do not employ this technique.

2. Clinical evidence, in the form of case reports are presented which indicate (a) that the use of "drops" makes refractive work more confusing, (b) that their use adds nothing to the value or the accuracy of refractive technique employed during an eye examination, (c) that refractive findings are more variable and therefore of less value when homatropine is used as a cycloplegic in eye examination work, and (d) that the claims of those oculists who suggest that only satisfactory examinations can

be made by those using the "drops" are unfounded.

3. Factual scientific evidence is presented which proves that the use of homatropine as a cycloplegic in eye examinations will produce findings of such variable and unreliable character as to confuse rather than help the examiner.

4. That "drops" or cycloplegics are therefore unnecessary in eye examining work and their use should be discontinued.

Carel C. Koch.

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CORRECTION

In the paper by Harry S. Friedman entitled "The Computation of Refracting Contact Lenses" an error occurred in setting one of the mathematical formulas. On page 445, Vol. 14, No. 12 of the AMERICAN JOURNAL OF OPTOMETRY under the paragraph headed "Effect of variation of thickness of saline meniscus," the minus sign, directly following the first bracket or parenthesis should precede it.

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ABSTRACTS

THE ETIOLOGY OF SQUINT, by A. Beilschowsky, M.D., American Journal of Ophthalmology, Volume 20, No. 5, May, 1937, pages 478-488.

In this article, the Etiology of Squint, Bielschowsky first discusses some of the various theories about squint which have been advanced during the last two centuries and points out their shortcomings. He seriously questions the refraction theory of squint. He points out to the fact that there are many hyperopes who have no convergent squint, and that there are many myopes who have no divergent squint. On the other hand, he contends that there are many cases of convergent or divergent squint who are emmetropic. He contends ametropia can not be considered as the sole cause of permanent squint, and that there must be some other etiological factors.

While we do not as yet know of all the factors which may assist in the production of squint, we do know of some factors. These he divides into three groups according to their different nature.

1. *Mechanical,* that may be due to (a) the faulty position of the two eyes relative to each other; (b) the anatomical relation between the eye balls; (c) the elasticity, length, insertion of the ocular muscles; (d) the volume and quality of the tissues behind the eye balls; (e) the size and form of the orbits and the bulbi.

2. *Faulty Innervation.* This may be in the form of excessive or spastic motor innervation.

3. *Mechanical and Nervous Disorders.* This is a combination of the factors listed under both 1 and 2.

Any of the above mentioned factors will cause only a *periodic squint* as long as the fusion faculty functions normally. If the fusion faculty is lost or weakened it may convert a periodic into a permanent squint.

Diagnostic Procedures. In order to determine the type of squint the patient has, Bielschowsky gives this method of diagnosis: Measure the angle of deviation several times under identical conditions. If the amount of squint is the same during each test the indications are that it is caused by mechanical anatomical factors. If the amount of squint varies under each test it points to an abnormal innervation as being the etiological factor.

Aniseikonia is another factor (of recent discovery) in the etiology of squint. This inequality of images may produce conditions prohibiting the sensory cooperation of the two eyes which may result in a condition of suppression, or it may disturb the motor activity, so that there may result a mental antipathy toward fusing of heterogeneous ocular images.

The author does not overlook the importance the visual act plays in strabismus and he differentiates between strabismus that arises in the first three or four years of life, and the strabismus that develops in later childhood or in adult life. In the former type there is nearly always a sensory anomaly, that is, there is no correspondence of the two foveae or other pair of corresponding retinal points, while in the latter type there will be found a correspondence of retinal points.

In conclusion the author points out that there are still a number of factors which enter into the etiology of squint about which we know very little, and until we do know more about these factors we can not hope to obtain the ideal therapeutic results. J. I. K.

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SUBJECTIVE TESTING. A. Knapp, The Dioptric Review, Oct.-Nov. 1931, p. 391.

Knapp writes on subjective eye testing, using a test chart, astigmatic dial and trial case. He makes much of the fact that these tests do supplement the objective tests and the time spent on them is frequently well spent. He suggests several small changes in subjective testing, however; (1) in taking the visual acuity he suggests that the optometrist, aided by a pointer, select a letter here and a letter there on the chart at random for the patient to read rather than letting the patient read all of the characters from top down. He also (2) condemns the use of a revolving astigmatic chart on which there have been drawn two sets of parallel

lines at right angles to each other. In Knapp's opinion this latter chart leads to inaccurate findings. C. C. K.

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BOOK NOTICES

DEVELOPMENTAL ABNORMALITIES OF THE EYE. Ida Mann, D.Sc., M.B., B.S. (London), F.R.C.S. (Eng.). Published in Cambridge at the University Press for the *British Journal of Ophthalmology* and in New York by the Macmillan Company. 444 pages, 223 illustrations and 18 color plates. Cloth. $15. 1937.

Ida Mann presents in this new book the processes which constitute the development of the human eye. Starting with her studies in the field of embryology she develops her thesis on through normal dvelopment into the various ocular abnormalities which she reviews in the greatest possible detail. She has had available much fine clinical material and her observations in the field of eye pathology are unique and outstanding. This work is of particular value to the practitioner interested in the scientific side of eye work as well as to the biologist and the embryologist.

C. C. K.

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